BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

Claims:

The embodiments of the invention in which an exclusive property or privilege is claimed are, therefore, defined as follows:

1. A method of cleaning comprising the steps of:

selecting a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid; wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid under standard conditions is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%.

selecting at least one washing adjuvant;

bringing said working fluid and adjuvant in contact with the fabric;

applying mechanical energy to provide relative movement within said fabric;

separating said working fluid from the fabric;

cooling the working fluid for decreasing the dissolved soils in the working fluid; and

filtering the permeate from the above step through a cross membrane filter.

2. The method of claim 1 including the further step of filtering the permeate from the above step through an adsorbent bed filter.

3. The method of claim 1 wherein vapors from said working fluid are treated by a high speed spinning disc which removes said working fluid and water vapor from the air stream.

4. The method of claim 3 including the step of cooling the vapor contacted by the spinning disc.

5. The method of claim 1 wherein said working fluid may have impurities of not more than approximately 20 %.

6. The method of claim 1 wherein the washing adjuvant is selected from a group consisting of: builders, surfactants, enzymes, bleach activators, bleach catalysts, bleach boosters, bleaches, alkalinity sources, antibacterial agents, colorants, perfumes, pro-perfumes, finishing aids, lime soap dispersants, composition malodor control agents, odor neutralizers, polymeric dye transfer inhibiting agents, crystal growth inhibitors, photobleaches, heavy metal ion sequestrants, anti-tarnishing agents, anti-microbial agents, anti-oxidants, linkers, anti-redeposition agents, electrolytes, pH modifiers, thickeners, abrasives, divalent or trivalent ions, metal ion salts, enzyme stabilizers, corrosion inhibitors, diamines or polyamines or alkoxylates, suds stabilizing polymers, solvents, process aids, fabric softening agents, optical brighteners, hydrotropes, water, suds or foam suppressors, suds or foam boosters, fabric softeners, antistatic agents, dye fixatives, dye abrasion inhibitors, anti-crocking agents, wrinkle reduction agents, wrinkle resistance agents, soil release polymers, soil repellency agents, sunscreen agents, anti-fade agents and mixtures thereof.

7. The method of claim 6 wherein a preferred surfactant for the system will have a hydrophilic-lipophilic balance from approximately 3 to 14.

8. A method of cleaning comprising the steps of:

selecting a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid;.

selecting at least one washing adjuvant;

bringing said working fluid and adjuvant in contact with the fabric;

applying mechanical energy to provide relative movement within said fabric;

separating said working fluid from the fabric;

cooling the working fluid for decreasing the dissolved soils in the working fluid; and

filtering said working fluid, wherein said working fluid may have impurities of not more than approximately 20 %..

9. The method of claim 8 wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid under standard conditions is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%.

10. The method of claim 9 including the step of filtering the permeate from the above step through a cross membrane filter.

11. The method of claim 10 including the further step of filtering the permeate from the above step through an adsorbent bed filter.

12. The method of claim 8 wherein vapors from said working fluid are treated by a high speed spinning disc which removes said working fluid and water vapor from the air stream.

13. The method of claim 12 including the step of cooling the vapor contacted by the spinning disc.

14. A wash cycle comprising the steps of:

providing relative movement between a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid, at least one washing adjuvant and a fabric to be cleaned;

circulating at least some of said working fluid to a cross membrane; and

re-circulating the filtered permeate back to the fabric to keep the soil level in said working fluid contacting the fabric below approximately 20 %.

15. The method of claim 14 wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid under standard conditions is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%.

16. The method of claim 14 wherein the relative movement step is accomplished by rotating said working fluid, washing adjuvant and fabric in one direction for less than approximately 30 seconds and reversing the direction of rotation whereby optimum cleaning is accomplished while minimizing any damage to the fabric.

17. The method of claim 16 wherein the relative movement step is accomplished by a random oscillation in opposite directions to optimize mechanical energy input while minimizing changes in the fabric from their initial state.

18. The method of claim 16 wherein the mechanical energy is inputted by ultrasonics.

19. The method of claim 16 wherein the mechanical energy is added by shaking.

20. The method of claim 14 wherein the washing adjuvant is selected from a group consisting of: builders, surfactants, enzymes, bleach activators, bleach catalysts, bleach boosters, bleaches, alkalinity sources, antibacterial agents, colorants, perfumes, pro-perfumes, finishing aids, lime soap dispersants, composition malodor control agents, odor neutralizers, polymeric dye transfer inhibiting agents, crystal growth inhibitors, photobleaches, heavy metal ion sequestrants, anti-tarnishing agents, anti-microbial agents, anti-oxidants, linkers, anti-redeposition agents, electrolytes, pH modifiers, thickeners, abrasives, divalent or trivalent ions, metal ion salts, enzyme stabilizers, corrosion inhibitors, diamines or polyamines or alkoxylates, suds stabilizing polymers, solvents, process aids, fabric softening agents, optical brighteners, hydrotropes, water, suds or foam suppressors, suds or foam boosters, fabric softeners, antistatic agents, dye fixatives, dye abrasion inhibitors, anti-crocking agents, wrinkle reduction agents, wrinkle resistance agents, soil release polymers, soil repellency agents, sunscreen agents, anti-fade agents and mixtures thereof.

21. The method of claim 20 wherein a preferred surfactant for the systems will have a hydrophilic-lipophilic balance from approximately 3 to 14.

22. The method of claim 14 including the step of controlling the amount of water in the system to less than approximately 5 % by dry weight of the fabric.

23. The method of claim 14 including the step of adding a water-in-working fluid emulsion to the fabric.

24. The method of claim 23 wherein the water-in-working fluid emulsion is added in vapor form.

25. The method of claim 23 wherein the water-in-working fluid emulsion is added in a spray-mist form.

26. The method of claim 23 wherein the step of adding a water-in-working fluid emulsion to the fabric occurs prior to introduction of said working fluid to the fabric.

27. The method of claim 14 including the steps of treating the fabric with said working fluid to remove loosely-bound soils; filtering a portion of said working fluid; followed by exposing the fabric to said working fluid and at least one washing adjuvant.

28. The method of claim 14 including repeating the relative movement step using an adjuvant differing from the adjuvant used in the previous steps for the purpose of completing a different type of cleaning.

29. The method of claim 14 wherein said working fluid and at least one adjuvant is sprayed on to the fabric while relative movement is being applied to the fabric and while a portion of the working fluid is being removed.

30. The method of claim 14 including the step of repeating the process using a working fluid to rinse adjuvant from the fabric and in which the rinse liquor is heated prior to contacting the fabric.

31. The method of claim 14 including the step of repeating the process using one of the following from the group consisting of: an adjuvant having a higher affinity for water; an adjuvant that decreases the viscosity of said working fluid; an anionic surfactant; and a cationic surfactant.

32. A method of drying fabrics in a closed-loop system comprising the steps of:

passing an air steam through fabric wetted with a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid;

heating the air stream to a temperature not exceeding approximately 30 °F below the flash point of said working fluid;

passing the air stream through the fabric;

cooling the air stream;

removing residual working fluid vapor and water vapor from the air stream;

heating the air stream to a temperature not exceeding approximately 30 °F below the flash point of said working fluid; and

circulating the air back through the fabric.

33. The method of claim 32 wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid under standard conditions is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%.

34. The method of claim 32 wherein the step of removing said residual working fluid vapor and water vapor comprises contacting the air stream with a desiccant for removal of the water from the air stream.

35. The method of claim 32 including a direct spray treatment for removing residual working fluid vapor and water vapor from the air stream comprising the steps of:

cooling said working fluid to less than room temperature;

spraying said cool working fluid into the air stream; and

collecting the condensate.

36. The method of claim 32 wherein a compressor driven refrigeration system having a condenser and an evaporator is provided, and said evaporator is used to provide at least some of the cooling specified in said step of cooling and the condenser is used to provide at least some of the heating specified in said step of heating.

37. A method of removing impurities from wash liquor comprising the steps of:

passing the wash liquor through a cross membrane filter;

moving the retentate to a concentrate filter to reduce said working fluid therein below approximately 5 %; and

recycling said wash liquor.

38. The method of claim 37 wherein said wash liquor comprises a non-reactive, non-aqueous, non-oleophilic, apolar working fluid.

39. The method of claim 38 wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%.

40. The method of claim 37 including the step of disposing the retentate from the concentrate filter by mechanical means once an allowable concentration is reached.

41. The method of claim 37 wherein the concentrate filter is a multi-compartment filter mechanism constructed and arranged to permit sequential exposure to the retentate.

42. The method of claim 41 wherein the multi-compartment filter moves the retentate to an accessible location for removal away from contact with working fluid.

43. An apparatus for cleaning fabrics with a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid comprising: a container for providing relative movement of the fabric to be cleaned;

means for introducing said working fluid and at least one washing adjuvant to said container;

means for withdrawing said working fluid from said container and returning it to said container;

means for passing an air stream through the fabric;

a heater constructed and arranged to heat the air stream prior to contacting the fabric to a temperature not exceeding approximately 30°F below the flash of said working fluid; and

a condenser constructed and arranged to cool the air stream leaving the fabric to a degree sufficient to remove working fluid and water vapor.

44. The apparatus of claim 43 wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid under standard conditions is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%

45. The apparatus of claim 43 wherein substantially all the materials contacted by said working fluid are selected from the group of commercial materials which prevent the generation of a spark.

46. The apparatus of claim 45 wherein substantially all of the materials contacted by said working fluid are an electrically conductive polymer.

47. The apparatus of claim 43 including means for introducing a water-in-working fluid emulsion into the container.

48. The apparatus of claim 43 wherein an adjuvant-dispensing chamber is included and which is constructed and arranged to introduce the adjuvant at a pre-selected period during the wash cycle.

49. The apparatus of claim 48 including a means for introducing a water-in-working fluid emulsion into the adjuvant-dispensing chamber.

50. The apparatus of claim 43 including a level sensor for detecting the level of said working fluid in the container, said level sensor being isolated from said working fluid and being constructed and arranged to record pressure changes in the level of said working fluid.

51. The apparatus of claim 43 including means for sensing the humidity of the fabric prior to contact by said working fluid.

52. The apparatus of claim 51 wherein conductivity is used to detect the initial moisture level of the fabric.

53. The apparatus of claim 43 including a temperature sensing means inside the container and means controlled by said sensing means to ensure that the temperature does not exceed 30 °F below the flash point of said working fluid.

54. The apparatus of claim 43 including a temperature sensor placed on the outlet of the heater and constructed and arranged to ensure that the temperature does not exceed 30 °F below the flash point of the working fluid.

55. Apparatus for cleaning fabric with a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid comprising:

a container for providing relative movement of the fabric to be cleaned;

means for introducing said working fluid and at least one washing adjuvant to said container;

a cross membrane filter;

a compressor driven refrigeration system means for removing heat from a cooling medium and discharging same;

a heat exchanger having a cooling medium side and a working fluid side; and

means for re-circulating working fluid from said container and circulating it through said working fluid side of said heat exchanger and then through filtering means.

56. The apparatus of claim 55 further comprising a sensing means constructed and arranged to control the temperature of said working fluid introduced to the cross membrane filter.

57. The apparatus of claim 56 further comprising a second filter constructed and arranged to receive the effluent of said first mentioned filter means, said second filtering means being an adsorbent bed filter.

58. The apparatus of claim 56 further comprising: means utilizing said heat discharged by said refrigeration means; and utilizing the same to heat said effluent of said first mentioned filtering means prior to be circulated to the adsorbent bed filter.

59. The apparatus of claim 55 including an infrared working fluid sensor constructed and arranged to control the level of working fluid remaining in the retentate of said second filtering means.

60. The apparatus of claim 55 including a storage tank constructed and arranged to store said working fluid between runs.

61. The apparatus of claim 60 constructed and arranged to provide a sanitation procedure before said working fluid enters the clean storage tank.

62. The apparatus of claim 55 including means for controlling the temperature of said working fluid before the working fluid enters the cross membrane filter.

63. The apparatus of claim 55 including means for controlling the temperature of said working fluid before the working fluid enters the adsorbent bed filter.

64. The apparatus of claim 55 including means to control the temperature of said fluid stream passing through said cooling means to achieve a temperature less than approximately 5 °C.

65. The apparatus of claim 55 including a concentrate filter constructed and arranged to receive the concentrate stream of the cross membrane filter.

66. The apparatus of claim 55 constructed and arranged to drain fluid from the fabric in said container and pass a stream of air through the fabric to dry the same.

67. The apparatus of claim 66 constructed and arranged to remove working fluid vapor from the air stream by means of a spinning disc which is cooled by said re-circulated working fluid.

68. The apparatus of claim 55 including a means for introducing a controlled amount of water to said container by means of a water-in-working fluid emulsion.

69. The apparatus of claim 68 constructed and arranged so that the emulsion is introduced at the start of the washing operation.

70. The apparatus of claim 68 constructed and arranged to include a vortex mixer to control droplet size of the emulsion.

71. The apparatus of claim 68 including a final filter constructed and arranged to remove permeate from solids and means utilizing the heat discharged form said refrigeration means to remove adsorbed chemicals from said final filter.

72. The apparatus of claim 55 constructed and arranged so that the rejected heat from the refrigeration means is passed through a phase change material for storage.

73. An apparatus for cleaning fabrics using a substantially non-reactive, non-aqueous, non-oleophilic, apolar working fluid and comprising:

a wash chamber for the fabric, working fluid, and at least one washing adjuvant;

means for draining working fluid from the wash chamber;

means for providing a stream of air through the wash chamber;

means for heating the air prior to introduction to the wash chamber;

means for passing some of the drained working fluid from the wash chamber through filtering means;

a storage tank for receiving the filtered working fluid removed from the wash chamber;

sensing means for determining the temperature at the outlet of the heating means; and

means controlled by said sensing element to keep the temperature of said air approximately 30 °F below the flash point of said working fluid.

74. The apparatus of claim 73 wherein said non-reactive, non-aqueous, non-oleophilic, apolar working fluid under standard conditions is further characterized by: a KB value less than approximately 30; a surface tension less than approximately 35 dynes/cm^2; and a solubility in water less than 10%.

75. The apparatus of claim 73 including an additional sensor at the air entrance to said wash chamber, said sensor being constructed and arranged to activate said means for controlling the temperature at approximately 30° F below the flash point.

76. The apparatus of claim 73 including means for sensing said working fluid concentration in the air outside the washing chamber, and means for disabling the system when the concentration of said working fluid in the air exceeds the lower flammability limit of said working fluid.

77. The apparatus of claim 76 wherein the sensing element is an infrared sensor constructed and arranged to provide a frequency range encompassing the range of the working fluid.

78. The apparatus of claim 73 including means for sensing the pressure drop across said filtering means; and means for disabling the cleaning apparatus when approximately only 10 % of the filter capacity remains.